

How BIM May Approach the Counterfactual Scenario of Inadequate Interoperability

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ABSTRACT

This paper investigates the intervention of Building Information Modeling (BIM) on the efficiency losses in the U.S. capital facilities industry. BIM is an intelligent parametric, object-based design methodology that is compelling the design community to transition away from unintelligent nonparametric, computer-aided drafting (CAD) processes. In 2004, the National Institute of Standards and Technology (NIST) commissioned the report, Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry. The report illustrates a \$15,800,000,000 USD (€11,600,000,000 EUR) annual efficiency losses generated from process waste in 2002. The NIST attributes the waste to the inadequate operability between CAD technologies, engineering, and software systems. The report relies on statistics compiled from nonparametric processes that the NIST measures against a counterfactual scenario. The author's purpose is to explore how a parametric database methodology enhances interoperability in the building sector by approaching the ideal hypothetical. The author performs the qualitative study in the artifact analysis tradition. The results indicate that BIM provides the infrastructure for improved interoperability, but does not longitudinally connect all stakeholders in terms of life cycle costing and has areas of inadequate interoperability.

Introduction

This paper investigates the intervention of Building Information Modeling (BIM) on the efficiency losses in the U.S. capital facilities industry. The author's purpose is to explore how a parametric methodology enhances interoperability in the building sector by approaching the ideal hypothetical. The author performs the qualitative study in the artifact analysis tradition. The paper addresses persons interested in BIM, interoperability, and life cycle costing.

The NIST Report

In 2004, the National Institute of Standards and Technology (NIST) commissioned the report, Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry [1]. The NIST estimates that process waste generates a \$15,800,000,000 USD (€11,600,000,000 EUR) of annual efficiency loss in 2002. The NIST attributes the waste to the inadequate interoperability between computer-aided drafting (CAD) technologies, engineering, and software systems. The facility life cycle is the longitudinal cost basis for the process waste. The life cycle phases in the building sector are 1) planning, engineering, and design (PED), 2) construction (C), 3) operation and maintenance (OM), and 4) decommissioning (D). This represents a cradle-to-grave analysis.

Design Communications

Computer-aided drafting is a nonparametric, design communications tool where the graphics exchange lacks intelligence. BIM is an intelligent parametric, object-based design methodology that is compelling the design community to transition away from CAD technologies [2]. BIM improves design performance by allowing project stakeholders to engage a single informational database. The stakeholders are 1) architects and engineers (AE), 2) general contractors (GC), 3) specialty fabricators and suppliers (SF), and 4) owners and operators (OO). When the architects and engineers simultaneously collaborate within a single three-dimensional (3D) BIM database, BIM dramatically alters the proportional weightings during the planning, engineering, and design phase. Figure 1 illustrates an accelerated design timeline that combines the MacLearney [3] and Birx [4] data. The forward shift implies a diminished process waste involving the design professional during for their contractual obligations. The remaining players have access to the database at the appropriate longitudinal timeframe.

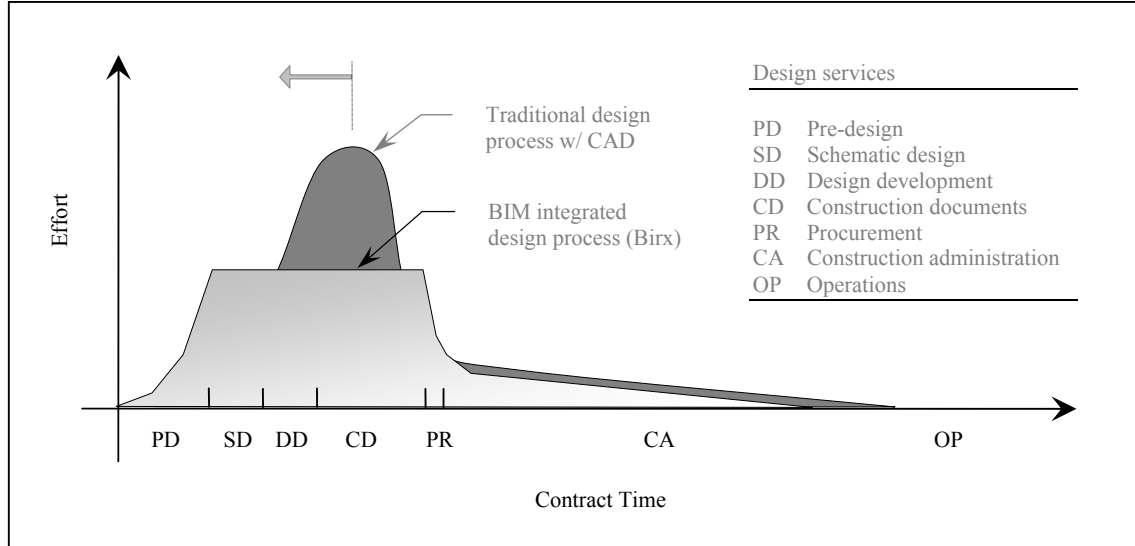


Figure 1: Reenergizing the PED Life Cycle Phase.

Counterfactual Scenario

Three activities categories are the cost basis for measuring efficiency losses. The activities comprise avoidance, mitigation, and delay. Avoidance costs are associated with reduced interoperability problems such as maintaining redundant CAD or paper exchange systems. Mitigation costs are related to performing redundant activities such as manually reentering data. Delay costs arise from problems such as idleness of building maintenance engineers awaiting correct information. These activities represent the various losses within the four stakeholder groups that follow the chronology of the four facility life cycle phases.

The NIST quantifies efficiency by evaluating inadequate interoperability against an ideal hypothetical. The hypothetical condition requires that “the electronic data exchange, management, and access are fluid and seamless. This implies that information needs be entered into electronic systems only once, and then it is available to all stakeholders instantaneously through information technology networks on an as-needed basis” [1]. This procedure is a counterfactual analysis. The method is not without controversy, and the NIST cited that Robert Fogel ‘pioneered’ the procedure. Fogel has since obtained a Nobel Prize in economics [5].

The coupling of BIM reducing process waste in the first life cycle phase and the basis of the ideal hypothetical being a fluid and accessible database leads to the questions of how interoperable is BIM and does the interoperability approach the zero floor of a counterfactual scenario?

The Interoperability of BIM Systems

The exploration involves the inadequate interoperability of BIM in terms of avoidance, mitigation, and delay costs across the life cycle for each stakeholder. Figure 2 illustrates the efficiency losses where CAD is the design communications tool of choice. The chart indicates the costs in USD for each of the four life cycle phases. The floor or baseline represents the counterfactual scenario where the ideal condition does not incur any losses. The BIM condition is situated somewhere between the CAD and ideal conditions.

Avoidance Costs

Avoidance costs increase in some areas and decrease in others for the AE stakeholders. Increased contributions occur due to the introduction of BIM. The transition requires the deployment of redundant software packages. During this period, the users accommodate both CAD and BIM systems to meet client needs. This negatively influences productivity for employees requiring training of the redundant systems. IT support staff incurs increased costs associated with maintaining the additional systems. This increased cost translates to only 13% of

the hypothetical ideal associated with AE avoidance costs during the PED life cycle phase. The remaining 87% exhibits a decrease in avoidance costs due to improved business management processes. BIM reduces the inadequate interoperability by performing such tasks as cost estimation and materials management, which also improves the contractors' efficiency. Addressing a larger scope of business processes is an area for improvement within the BIM model. Meeting the needs of design professionals dominates the current direction of BIM technology. Further development should embrace the other stakeholders by incorporating embedded modules for document management, facility planning and scheduling, information request processing, maintenance planning, and management, project management, and start-up and commissioning. The list is not comprehensive, but indicates that the building sector should envision BIM as more than just a design and construction tool. The single database provides an infrastructure suitable to plug-ins for business processes of all stakeholders.

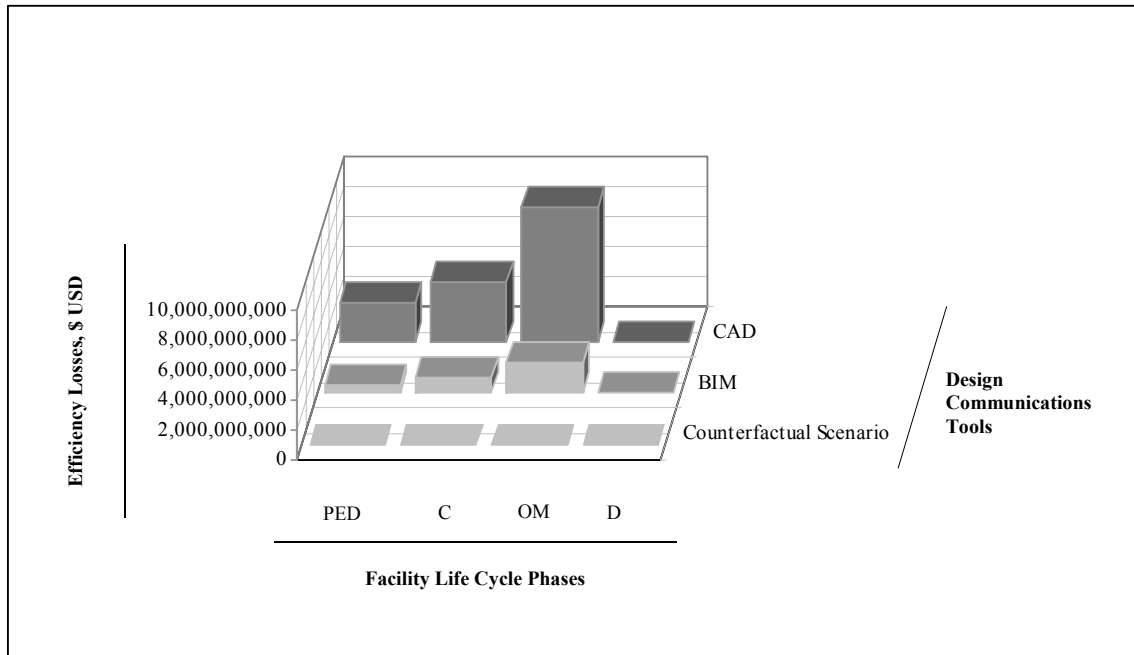


Figure 2: Inadequate Interoperability Costs.

Mitigation Costs

Manual reentry costs represent 80% of the AE inadequate interoperability costs for the PED life cycle phase [1]. This is specific replication of work performed either internally or externally. An architect incorporating an engineer's design within their architectural drawings is an example of manual reentry. BIM greatly reduces the mitigation costs by allowing other design professionals to work simultaneously within the same 3D model. The BIM informational database accommodates multiple users by creating independent worksets for each task. A central file houses each independent and secure workset. BIM decreases the 19% costs incurred due to design and construction information verification. The design professionals have process waste through time spent identifying the correct version of a file. BIM has an embedded automatic change management system that will keep the information current.

The OO stakeholder has a \$4,790,000,000 USD (€3,520,000,000 EUR) efficiency loss due to operations and maintenance, information verification costs during the OM life cycle phase [1]. This represents 30% of the entire inadequate interoperability for the counterfactual scenario by the OO. Losses include time spent acquiring current information since as-built drawings, if they exist, are not commonly updated. A single BIM module for the OO business process of planning and scheduling that links the preventative maintenance and repair of building components would alleviate a majority of the efficiency losses. The software exists independently for

building owners, but the losses are associated with referencing the correct drawings, products, and warranties tied to contract document. A notable omission is asset management during the OM phase. The building will most likely have multiple owners throughout its lifetime. The NIST does not acknowledge these stakeholders.

Delay Costs

The AE, GC, and SF stakeholders have minimal contributions to the delay costs. The OO incurs 99% of the efficiency losses. In particular, the NIST identifies that \$1,500,000,000 USD (€1,100,000,000 EUR) is due to idled employees that do not have the correct information available [1]. One concern from owners is that actions taken on insufficient information may lead to more frequent repairs. Although the AE, GC, and SF stakeholders do not incur mentionable delay costs, they do create the infrastructure, which bears the largest efficiency losses. The OO alone bears \$6,900,000,000 USD (€5,080,000,000 EUR) of the losses accounting for 44% of the aggregate inadequate interoperability.

Decommissioning Costs

The NIST did not include costs for decommissioning in their cost matrix. This may be attributed to the intent of capturing the current costs for a calendar year as opposed to true lifetime costs. The respondents may not have had a decommissioning occurring during 2002.

Conclusions

Although the data is too premature to determine exact quantitative values for inadequate operability when each stakeholder deploys BIM, one may interpret its broader implications. The BIM infrastructure is an ideal platform to establish longitudinal stakeholder relationships over the facility life cycle. The information database is intelligent where each element has physical characteristics and relationships. This allows for future interoperability with other software programs and undefined stakeholders. In particular, the building sector should investigate plug-ins for business processes specifically suited to the OO community where a majority of the inadequate interoperability exists during the OM phase.

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